

TRANSMISSION METHOD AND TRANSMISSION SYSTEM  
AS WELL AS COMMUNICATIONS DEVICE

FIELD OF THE INVENTION

The present invention relates to a transmission method and a transmission system as well as a communications device capable of transmitting and receiving a data signal and an information signal among a plurality of devices by full-duplex operation.

BACKGROUND OF THE INVENTION

As information devices have been digitized, high-speed serial communications utilizing digital signals have been adopted in a wide field which covers inter-LSI (large-scale integration) data transmission to wireless and optical-fiber telecommunications.

It is common in digital communications that a device

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on a side of the other party with whom data are communicated should transmit not only communication data but also timing information to enable accurate data sampling.

However, in order to reduce the number of lines to be used in communications, the high-speed serial communications for the most part avoid the use of an exclusive line for transmitting data containing timing information, other than a line to transmit serial data (communication data). Instead, in a serial data transmission system, in order to enable an input stage of a data receiving section thereof to accurately receive serial data which is transmitted via a transmission line, there is provided a clock data recovery (CDR) circuit which generates a clock of a constant period in synchronism with the serial data so as to correct (recover) a timing of the serial data based on the clock thus generated.

The CDR circuit is made up of a clock reproducing circuit for reproducing (generating) a clock from serial data, and a re-timing circuit for correcting a timing of the serial data based on the reproduced clock thus reproduced by the clock reproducing circuit so as to output it as re-timed data.

Meanwhile, an attempt to achieve bidirectional full-

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crosstalk is "1". Assuming that a slice level which determines whether a signal is "0" or "1" is set at the center of an amplitude of a received signal, the crosstalk raises the slice level only by a half amplitude of the crosstalk. As a result, the slice level deviates off the center of the amplitude of the light signal, thereby occurring the crosstalk jitter.

Further, in the case of the waveform on the left side in the lower half of Fig. 12, i.e., when the crosstalk is "0", a timing at which a signal rises across the slice level delays, and a timing at which the signal falls across the slice level becomes earlier.

Likewise, in the case of the waveform on the right side in the lower half of Fig. 12, i.e., when the crosstalk is "1", a timing at which a signal rises across the slice level becomes earlier, and a timing at which the signal falls across the slice level delays.

Since the crosstalk jitter occurs with this mechanism, it depends on a relationship between a pattern and a phase of the light signal and those of the crosstalk whether a condition in which the timings of the rise and fall are steadily displaced may occur, that may further effect a continuous one-way deviation in a data transition. In this respect, the crosstalk jitter is distinguished from the common system jitter.

Particularly, in a transmission system under the influence of the crosstalk, when a home port and a port of the other party have close clock speed, the continuous transmission of a periodic waveform (a single pattern) as a signal other than a data signal, for example a signal containing such status information as to indicate a connection condition between devices (hereinafter referred to as "information signal") from the both ports results in unbalanced jitter, thereby offering worse jitter tolerance (an indicator which shows to what extent jitter can be tolerated in a receiving system).

Here, as shown in Fig. 15, a jitter distribution under the influence of the crosstalk becomes either a jitter distribution (advanced jitter distribution) which is made up of a jitter component at an advanced stage of time or a jitter distribution (retarding jitter distribution) which is made up of a jitter component at a retarded stage of time.

Therefore, when a data pattern with which the deviation in the data transition thus continuing in a single direction persists, a center X of the original jitter distribution (eye) shifts, thereby locking the foregoing CDR circuit at a center Xa or X1 of the jitter distributions of the advanced or retarding jitter component, respectively.

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and sampling point is, as in the case of the common system jitter,  $(T/2) - (J/2)$ . Namely, taking into consideration an unbalanced deviation in the transition, it is understood that the crosstalk jitter has an effect which is twice the effect of the common system jitter.

Thus, the crosstalk jitter in a transmission line which is susceptible to crosstalk is, for the CDR circuit, more problematic than the common system jitter because it requires the CDR circuit to improve performance. Therefore, there arises a problem such that the cost of the CDR circuit increases or, at worst, the CDR circuit cannot be attained at all.

#### SUMMARY OF THE INVENTION

It is an object of the present invention to provide a transmission method in which an adverse effect of crosstalk jitter in a transmission line susceptible to crosstalk is minimized so as to reduce a margin between the transition and sampling point of a signal, thereby suppressing the cost of a CDR circuit.

An example of a transmission system adopting the transmission method according to the present invention may be a transmission system capable of bidirectional full-duplex optical communications based on a single wavelength.

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period of time when there is no communication over a bus and the bus enters an idling state accordingly. In that case, when a home port and a port of the other party have close clock speed, the continuous transmission of a periodic waveform from the both ports results in unbalanced jitter, thereby offering worse jitter tolerance. The jitter tolerance is an indicator which shows to what extent jitter can be tolerated in a receiving system.

In the present invention, in order to prevent the worse jitter tolerance, improvements are made in a conventional system which consecutively transmits a single control code, and in order to reduce interaction between transmitting and receiving signals, a random data code is transmitted simultaneously with a control code.

Namely, in order to solve the foregoing problems, the transmission method according to the present invention capable of transmitting and receiving a data signal and an information signal among a plurality of devices by full-duplex operation has an arrangement in which, when the information signal consecutively repeats a single pattern, a different pattern is inserted between the same patterns before transmitting the single patterns.

In the transmission method according to the present

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This prevents the center of a jitter distribution under the effect of crosstalk from deviating off the center of the original jitter distribution. Here, the center of the jitter distribution, as shown in Fig. 15, comes to a position averaged from both peaks of retarding and advanced jitter components, that is, substantially the same position of a center X of the original jitter distribution.

Moreover, the center of the jitter distribution under the effect of crosstalk can be made closer to the center of the original jitter distribution. Therefore, even when affected by crosstalk due to the information signal, the center of the jitter distribution comes closer to the center of the original jitter distribution. Therefore, as shown in Fig. 15, required is a less margin between the transition and sampling point of a signal for accurate sampling of a signal, than a conventional margin which includes a whole jitter distribution including both

retarding and advanced states when viewed from the original jitter distribution.

Consequently, a CDR circuit for making sampling of a signal can be manufactured at low cost.

Additional objects, features, and strengths of the present invention will be made clear by the description below. Further, the advantages of the present invention will be evident from the following explanation in reference to the drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram showing a transmitter according to a First Embodiment of the present invention.

Fig. 2 is a diagram showing a receiver according to the First Embodiment of the present invention.

Fig. 3 is a diagram showing a transmitter according to a Second Embodiment of the present invention.

Fig. 4 is a diagram showing a transmitter according to a Third Embodiment of the present invention.

Fig. 5 is a diagram showing a receiver according to a Fourth Embodiment of the present invention.

Fig. 6 is a diagram showing one embodiment in which two devices which are related to a transmission method and a transmission system according to the present invention are connected by a full-duplex channel.

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Fig. 7 is a diagram showing one embodiment in which a plurality of devices which are related to the transmission method and transmission system according to the present invention are connected by the full-duplex channel.

Fig. 8 is an explanatory view showing one example of a transmission pattern of a transmission method according to the First Embodiment of the present invention and is a diagram showing a case where a pattern is inserted at a random interval.

Fig. 9 is an explanatory view showing one example of the transmission pattern of the transmission method according to the First Embodiment of the present invention and is a diagram showing a case where a pattern is inserted at a fixed interval.

Fig. 10 is an explanatory view showing one example of a transmission pattern of a transmission method according to the Second Embodiment of the present invention.

Fig. 11 is an explanatory view showing one example of a transmission pattern of a transmission method according to the Third Embodiment of the present invention.

Fig. 12 is a diagram showing a generation mechanism of crosstalk jitter.

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Fig. 13 is a diagram showing a sampling point deviation.

Fig. 14 is a graph showing a jitter distribution free from an influence of crosstalk.

Fig. 15 is a graph showing a jitter distribution under the influence of crosstalk.

#### DESCRIPTION OF THE EMBODIMENTS

A transmission method according to the present invention is the method for transmitting and receiving a data signal and an information signal among a plurality of devices by full-duplex communications. When transmitting the information signal, where the information signal is a signal having a single pattern which is continuously repeated, a different pattern is inserted between these single patterns before transmission. To be more specific, part of the signal having the continuously repeated single patterns is converted into a different pattern. This will be discussed later in detail.

Further, in the present embodiment, as an example of a transmission system, a transmission system capable of bidirectional full-duplex optical communications based on a single wavelength in which a single optical fiber is adopted as a transmission line will be explained.

The following will explain the transmission of a signal for conducting arbitration (arbitration for obtaining a license to use a bus) in IEEE Std 1394-1995 that is a standard set to perform a high-speed transmission of a large quantity of data among information devices such as computers and digital cameras, and arbitration in high-speed serial bus communications compliant with the arbitration in the IEEE Std 1394-1995.

Note that, the present invention is not limited to a transmission system pursuant to the foregoing standard, and, for example, it can be adopted in other serial transmission systems such as a USB (Universal Serial Bus). Moreover, it is applicable to wireless communications in addition to the optical-fiber communications.

In an arbitration period for the IEEE Std 1394-1995 and an arbitration period for the high-speed serial bus communications compliant therewith, devices communicate with each other by transmitting nine types of status information. Namely, there exist codes respectively representing nine types of status.

Here, one of the codes representing status information is an IDLE code which indicates a stand-by state. The IDLE code remains transmitted for a long

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period of time when there is no communication over a bus and the bus enters an idling state accordingly. In that case, when a home port and a port of the other party have close clock speed, the continuous transmission of a periodic waveform from the both ports results in unbalanced jitter, thereby offering worse jitter tolerance. The jitter tolerance is an indicator which shows to what extent jitter can be tolerated in a receiving system.

In the present invention, in order to prevent the worse jitter tolerance, improvements are made in a conventional system which consecutively transmits a single control code, and in order to reduce interaction between transmitting and receiving signals, a random data code is transmitted simultaneously with a control code.

The transmission system according to the present embodiment, as shown in Fig. 6 for example, has an arrangement in which a device (1) 601 composing a communicator is connected to a device (2) 602 composing a communicator at an end of the other party via a full-duplex channel 607 which is a transmission line made of one single optical fiber.

More specifically, in the foregoing communication system, the device (1) 601 is made up of a transmitter (1) 603 and a receiver (1) 604, and the device (2) 602 is

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made up of a transmitter (2) 605 and a receiver (2) 606, and the full duplex channel 607 connects therebetween.

Here, an attempt to attain bidirectional full-duplex operation based on a single wavelength by adopting a single optical fiber causes crosstalk to adversely affect reception light, the crosstalk being such that reflection of transmission light at, for example, an end surface of an optical fiber causes the transmission light to be incident onto a photoreceptor of a home node. The crosstalk causes system jitter, and it depends on a relationship between a pattern and a phase of the signal light and those of the crosstalk whether a condition in which the timings of the rise and fall are steadily displaced may occur, that may further effect a continuous one-way deviation in a data transition.

The detailed explanation of transmitters and receivers of respective devices according to the present invention which are attained in order to solve the foregoing problem will be provided in each embodiment shown below. Note that, the present invention is not limited to the use between two devices, and as shown in Fig. 7, it is applicable among a plurality of devices, for example, in the case of wireless communications.

Fig. 7 shows an example of the use of four devices in the wireless communications, where a device (1) 701 is

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made up of a transmitter 705 and a receiver 706, a device (2) 702 is made up of a transmitter 707 and a receiver 708, a device (3) 703 is made up of a transmitter 709 and a receiver 710, and a device (4) 704 is made up of a transmitter 11 and a receiver 712.

With the foregoing as preconditions, a transmission method and a transmission system as well as a communications device according to the present invention will be described in detail in each embodiment below.

[FIRST EMBODIMENT]

The following will describe a communications device according to a First Embodiment of the present invention with reference to Figs. 1 and 2.

The communications device includes a transmitter 100 shown in Fig. 1 and a receiver 200 shown in Fig. 2.

The transmitter 100, as shown in Fig. 1, includes a transmitting section 101, a multiplexer 102, a data code encoder 103, a status information code encoder 104, a multiplexer 105, a data/status information signal control section 106, a random number generating section 107, a data/status information signal generating section 108, a data code generating section 109, and a status information code generating section 110.

The following will explain respective functions of blocks composing the transmitter 100.

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The transmitting section 101 is a section to transmit one bit each of a data code or status information code received from the multiplexer 102, in accordance with a constant clock.

The multiplexer 102 is a section to switch output of a code to the transmitting section 101, between a data code and a status information code, judging from a control signal from the data/status information signal control section 106.

The data code encoder 103 and status information code encoder 104 are sections to perform encoding in some manner.

The multiplexer 105 is a section to switch output of a code to the data code encoder 103, between a data code from the data code generating section 109 and a random code generated from the random number generating section 107, judging from a data/status information signal outputted from the data/status information signal generating section 108.

The data/status information signal control section 106 is a section to generate a control signal to be outputted to the multiplexer 102 based on a data/status information signal from the data/status information signal generating section 108.

The random number generating section 107 is a

The data/status information signal generating section 108 is a section to generate a data/status information signal which indicates whether a currently transmitted code is a data code or a status information code.

The status information code generating section 110 is a section to generate a status information code.

Meanwhile, a control signal to be generated in the data/status information signal control section 106 is generated based on a data/status information signal which indicates whether a currently transmitted code from the data/status information signal generating section 108 is

More specifically, when the data/status information signal indicates that the currently transmitted code is a data code, the data/status information signal control section 106 outputs a control signal so that the multiplexer 102 outputs a code (data code) to be outputted from the data code encoder 103, to the transmitting section 101.

On the other hand, when the data/status information signal indicates that the currently transmitted code is a status information code which repeats a single pattern, the data/status information signal control section 106 outputs such a control signal as to control output of a code from the multiplexer 102 to the transmitting section 101, the code being selected from a code (status information code) outputted from the status information code encoder 104 to the multiplexer 102 and a code (random code) outputted from the data code encoder 103 to the multiplexer 102, by a random or regular switch.

Further, when the data/status information signal indicates that the currently transmitted code is a status information code which does not repeat a single pattern, the data/status information signal control section 106

outputs such a control signal as to control that the multiplexer 102 outputs only a code (status information code) from the status information code encoder 104, to the transmitting section 101.

When the data/status information signal indicates that the currently transmitted code is a status information code which repeats a single pattern, and when the multiplexer 102 randomly switches output of a code between the code (status information code) from the status information code encoder 104 and the code (random code) from the data code encoder 103, the data/status information signal control section 106 is enabled by the random number generating section provided therein to switch data/status information signals at a random interval and output the selected data/status information signal to the multiplexer 102.

Thus, the switch of output from the multiplexer 102 at a random interval prevents transmission of a continuously repeated single pattern.

Meanwhile, when the data/status information signal indicates that the currently transmitted code is a status information code which repeats a single pattern, and when the multiplexer 102 regularly switches, i.e., switches at a fixed interval, output of a code between the code (status information code) from the status information

code encoder 104 and the code (random code) from the data code encoder 103, the data/status information signal control section 106 is enabled by a counter provided therein to switch data/status information signals at a specific counter value and output the selected data/status information signal to the multiplexer 102.

Thus, even when converting a pattern to be transmitted at a fixed interval, there can be attained the same effect as in the case of switching output from the multiplexer 102 at a random interval.

Further, the receiver 200 that is a component of the communications device according to the present embodiment, as shown in Fig. 2, includes a receiving section 201, a decoder 202, a data/status information judging section 203, a multiplexer 204, a latch section 205, a data code receiving section 206, and a status information code receiving section 207.

The following will explain respective functions of blocks composing the receiver 200.

The receiving section 201 is a section to transmit to the decoder 202, one bit each of data transmitted by a transmitter of a communications device of the other party, as received.

The decoder 202 is a circuit to decode a signal subject to encoding in some manner and is a section to









transmission of the pattern to be transmitted is thus fixed, a device at a receiving end can check the pattern to be transmitted at this interval.

The following will explain one example of the transmission patterns in the transmission method according to the First Embodiment of the present invention with reference to Fig. 8.

A transmission pattern as shown in Fig. 8 shows a case where a pattern is inserted at a random interval. Here, assuming that transmission patterns IDLE and Rand\_Data (random data) are respectively abbreviated to I and R, the transmission pattern of Fig. 8 can be given with these symbols as -[III]-R-[III]-R-[II]-R-[IIII]-R-. This indicates that R is inserted at a random interval such that the number of I becomes 3, 3, 2, then 4. Note that, in the present embodiment, R is inserted at a random interval only with respect to a single pattern; however, the present invention is not limited to this.

The following will explain another example of the transmission patterns in the transmission method according to the First Embodiment of the present invention with reference to Fig. 9.

A transmission pattern as shown in Fig. 9 shows a case where a pattern is inserted at a fixed interval. Here, assuming that transmission patterns IDLE and

Rand\_Data (random data) are respectively abbreviated to I and R, the transmission pattern of Fig. 9 can be given with these symbols as -[III]-R-[III]-R-[III]-R-[III]-R-. This indicates that R is inserted at a fixed interval such that the number of I becomes 3, 3, 3, then 3. Note that, in the present embodiment, R is inserted at a fixed interval with respect to a single pattern; however, the present invention is not limited to this.

Note that, in the present embodiment, explanation of a pattern to repeat a single pattern has been made with an IDLE code indicating a stand-by state as an example, though not limited to this. Likewise, any information signals including a control code for the use in a transmission system adopting an optical fiber can be used if transmitted after inserting a random data code between the single patterns, thereby reducing an adverse effect of crosstalk and preventing deviation in a jitter distribution.

An optical transmission system such as "OP i. LINK (registered trademark)" have the following control codes as shown in Table 1.

(continued)

[TABLE 1]

The List of Control Codes

Control Code
PREABLE
P_IDLE
S_TPBIAS_DISABLE
S_IDLE
P_TPBIAS_DISABLE
REQUEST
GRANT
PARENT_NOTIFY
HIGHER_SPEED
DATA_PREFIX
CHILD_NOTIFY
IDENT_DONE
KEEP_SPEED
DATA_END
SPEED200
SPEED400
BUS_RESET
SYNC_CHARACTER
END_NEGOTIATION
SUSPEND
DISABLE_NOTIFY

Among the control codes shown in Table 1, when the control codes except DATA\_RREFIX, DATA\_END, SPEED200 and SPEED400 are transmitted, they are transmitted after

inserting random data codes between the control codes. Note that, it goes without saying that the present invention is applicable to any other systems having a control code which consecutively repeats a single pattern.

[SECOND EMBODIMENT]

The following will explain a Second Embodiment of the present invention.

With respect to the transmitter 100 of Fig. 1 that is the First Embodiment, in the present Second Embodiment is added a function such that when a single pattern to be transmitted is changed into a pattern indicative of other information at a timing to transmit random data, a transmission pattern (pattern indicative of other information) after the change is transmitted without inserting random data. This will be explained below.

In Fig. 3, a transmitter 300 includes a transmitting section 301, a multiplexer 302, a data code encoder 303, a status information code encoder 304, a multiplexer 305, a data/status information signal control section 306, a random number generating section 307, a data/status information signal generating section 308, a data code generating section 309, a status information code generating section 310, a status information comparing section 311 and a latch section 312.

The following will explain respective functions of blocks composing the transmitter 300, provided that explanation of the blocks having the same functions as with the First Embodiment, i.e., the blocks except the data/status information signal control section 306, the status information comparing section 311 and the latch section 312, will be omitted here.

Based on a data/status information signal from the data/status information signal generating section 308 and a status information comparing signal from the status information comparing section 311, the data/status information signal control section 306 generates a control signal to be outputted to the multiplexer 302.

The status information comparing section 311 makes a comparison between a status information code which is outputted from the status information code generating section 310 and a status information code which was previously received and is outputted from the latch section 312, so as to generate a comparison result signal to be outputted to the data/status information signal control section 306. Further, the status information comparing section 311 outputs a status information code received from the status information code generating section 310 intact to the latch section 312.

The latch section 312 holds a status information

code which is outputted from the status information comparing section 311.

Here, when, judging from a signal indicative of a comparison result outputted from the status information comparing section 311, the previously received status information code and the currently transmitted status information code are different, the data/status information signal control section 306 outputs a control signal to the multiplexer 302 so that the multiplexer 302 transmits the status information code intact even when there comes a timing to insert a data code.

Thus, a problem seen in the First Embodiment such that transmission is delayed because, regardless of whether or not a status information code is changed, a data code is inserted at every timing to do so without transmitting a status information code can be solved by additionally providing the circuits of the present Second Embodiment.

Fig. 10 is an explanatory diagram showing one example of a transmission pattern in the transmission method according to the present Second Embodiment. Here, assuming that transmission patterns Rand\_Data (random data), IDLE and status information except IDLE are respectively abbreviated to R, I and S, a transmission pattern as shown in Fig. 10 can be given with these





The 8B10B encoding system is such that 8-bit data representing signal information is converted into 10-bit data so as to be transmitted to a transmission line. Digital data which is dealt with under the present transmission system is converted at a transmitting end, for example, from 8-bit data in which 1 code includes 8 bits into 10-bit data in which 1 code includes 10 bits, that is called an 8-10 bits conversion, and transmitted as 10-bit data.

Thereafter, at a receiving end, the original 8 bit-data is restored from the received 10-bit data by a 10-8 bits conversion. Thus, 10-bit data used in a transmission system includes various codes respectively having the following three different types of 10-bit structures: (i) 10 bits consisting of more "1" than "0"; (ii) 10 bits consisting of more "0" than "1"; and (iii) 10 bits equally consisting of "1" and "0".

Here, in order to indicate the state of each number "1" or "0" is adopted a concept called Running Disparity (RD). According to this, in the case of the above type (i), it is considered that the Running Disparity (RD) is 'positive', and in the case of the above type (ii), the RD is 'negative', and further, in the case of the above type (iii), the RD is 'neutral'.

In addition, a code of the above type (i), a code of

the above type (ii) and a code of the above type (iii) are respectively referred to as a "code of the positive RD", a "code of the negative RD" and a "code of the neutral RD". Each individual information is given two codes, provided that some information may be given two identical codes.

Further, in the selection of 10-bit data, when a code provided immediately before is of the negative RD, a code of the positive or neutral RD is selected, and when a code provided immediately before is of the positive RD, a code of the negative or neutral RD is selected.

Here, as an example of an IDLE code to indicate a stand-by state, "0011111010" of the positive RD and "1100000101" of the negative RD will be discussed.

When CRD (Current Running Disparity) which is the RD of a code provided immediately before is negative (-), an IDLE code "0011111010" of the positive RD is selected, and when the CRD which is the RD of a code provided immediately before is positive (+), then an IDLE code "1100000101" of the negative RD is selected. Hereinafter, the above "0011111010" and "1100000101" are respectively referred to as "+IDLE code" and "-IDLE code".

Here, with respect to each signal at the

transmitting end is inserted, for example, either of the +IDLE code of the positive RD and the -IDLE code of the negative RD, depending on whether a code provided immediately before is of the negative or positive RD. For example, in the case where a code is inserted at the transmitting end, when the code provided immediately before is of the negative RD, the positive +IDLE code is inserted, and when the code provided immediately before is of the positive RD, the negative -IDLE code is inserted.

Fig. 4 shows the Third Embodiment of the present invention which is a transmitter to realize the foregoing transmission method and system. In Fig. 4, a transmitter 400 includes a transmitting section 401, an encoder 402, an internal parameter control section 403 and a code generating section 404.

The following will explain respective functions of blocks composing the transmitter 400.

The transmitting section 401 transmits one bit each of a code transmitted from the encoder 402, according to a constant clock.

The encoder 402 encodes a code received from the code generating section 404 by the 8B10B encoding.

The internal parameter control section 403 causes random variation of an internal parameter generated in

the encoder 402.

The code generating section 404 generates a code and outputs it to the encoder 402.

Note that, as to the internal parameter control section 403, in the case of a common 8B10B encoding on one hand, when consecutively transmitting IDLE patterns, an internal parameter RD alternately varies between positive and negative. In the case of the present Third Embodiment on the other hand, providing a random number generator within the internal parameter control section 403 causes random variation of an internal parameter, thereby preventing the consecutive repeated transmission of a single pattern. Here, as a method for controlling an internal parameter, three methods for changing an internal parameter at a different timing will be explained.

First of all, a first method is to allow an internal parameter to vary every time at random. This method provides a simple circuit but reduces an effect of RD. As a second method can be adopted a method to allow an internal parameter to vary periodically. By providing a counter within the internal parameter control section 403, for example, causes random variation of an internal parameter at a specified counter value. The present method provides the effect of RD and is most preferable





synchronization circuit 502 having the functions as explained referring to Fig. 2 of the First Embodiment will be omitted here.

The bit synchronization circuit 502 outputs a bit string which was received by the receiving section 501 to the decoder 503 in synchronism with an internal clock.

The present invention is capable of random variation of a crosstalk light level at the transition of a signal, thereby preventing, or suppressing, that a sampling point at which a CDR circuit makes sampling of a signal deviates off the center of the original eye.

Further, the present embodiment offers a sort of scrambling effect, and therefore it is effective as a countermeasure against EMI. A conventional scrambling technique requires synchronization for scrambling between communications devices, that is not required in the present invention. Moreover, the stable output of a clock synchronizing a receiving signal, and data is available.

As discussed, a transmission method according to the present invention capable of transmitting and receiving a data signal and an information signal among a plurality of devices by full-duplex operation has an arrangement in which, in the case where the information signal consecutively repeats a single pattern, a pattern



different from the single pattern is inserted before transmitting the single pattern.

Therefore, in the case where the information signal consecutively repeats a single pattern, transmitting the information signal by inserting a different pattern between the same patterns can cause random variation of a signal level of crosstalk which is generated from the information signal while the information signal is transmitted through a transmission line.

This prevents a center of a jitter distribution under the effect of crosstalk from deviating off the center of the original jitter distribution.

Moreover, the center of the jitter distribution under the effect of crosstalk can be made closer to the center of the original jitter distribution. Therefore, even when affected by crosstalk due to an information signal, the center of a jitter distribution is made closer to the center of the original jitter distribution, thereby requiring a less margin between the transition and sampling point of a signal for the accurate sampling of a signal, than a conventional margin which includes a whole jitter distribution including both retarding and advanced states when viewed from the original jitter distribution.

Consequently, a CDR circuit for making sampling of

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a signal can be manufactured at low cost.

Further, the outputting and reception of a data signal and an information signal may be performed among the plurality of devices, and particularly between two devices.

With this arrangement, it is possible to perform bidirectional full-duplex operation based on a single waveform by adopting a single optical fiber as a transmission line. Here, also, it is prevented that a system jitter due to crosstalk adversely affects reception light, the crosstalk being caused by, for example, reflection of transmission light at an end surface of the optical fiber.

Further, the aforesaid different pattern may be inserted between the same patterns at a random interval.

With this arrangement, a signal level of crosstalk at the transition of a signal can be caused to vary at random, thereby preventing, or suppressing, that a sampling point at which a CDR circuit makes sampling of a signal deviates off the center of the original jitter distribution (eye).

Further, the aforesaid different pattern may alternatively be inserted between the same patterns at a fixed interval.

With this arrangement, since an interval between the











of the two types of codes is selected and transmitted in accordance with an internal parameter, the internal parameter is caused to vary at random before transmitting the code.

With this arrangement, when the information signal consecutively repeats a single pattern in transmission, two types of codes having different polarities and the single pattern are transmitted at random. Therefore, a random signal level of crosstalk generated in a transmission line is attained, thereby preventing one-way deviation in a jitter distribution due to occurrence of crosstalk.

Further, there is adopted a coding method in which two types of codes respectively having reverse "1" and "0" correspond to one information, and a code is selected from two types of tables in accordance with an internal parameter, thereby diverting thereto a table selection function which is required for coding, and reducing a circuit scale.

Further, it may be arranged such that variation points of a reception signal are detected so as to generate a clock to synchronize the reception signal based on an average interval between the variation points, and the data or information signal is received based on the clock thus generated.



With this arrangement, it is possible to stably outputs the clock synchronizing the reception signal, and data.

Further, a transmission system capable of transmitting and receiving a data signal and an information signal among a plurality of devices by full-duplex operation adopts the foregoing transmission method.

Further, a transmission method according to the present invention is also adopted in the following communications device.

More specifically, a communications device capable of transmitting and receiving a data signal and an information signal among a plurality of devices by full-duplex communication includes: a transmitter for transmitting the data and information signals; and a receiver for receiving the data and information signals, wherein: the transmitter includes a random pattern generating section for randomly generating a pattern different from the information signal, an identification signal generating section for generating an identification signal which indicates whether a signal to be transmitted is the data signal or the information signal, and a transmitting section for transmitting the data or information signal based on the identification

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a conventional margin which includes a whole jitter distribution including both retarding and advanced states when viewed from the original jitter distribution.

Consequently, a CDR circuit for making sampling of a signal can be manufactured at low cost.

The aforesaid receiver may include a signal judging section for judging whether a reception signal is the data signal or the information signal, and a setting section for setting a time period for receiving the data signal and a time period for receiving the information signal in accordance with a result of judgment by the signal judging section.

With this arrangement, the receiver can make a distinction between the time period for receiving the data signal and the time period for receiving the information signal, thereby solving a problem such that the data signal is received in the time period for receiving the information signal.

Further, the receiver may include a bit synchronization circuit for detecting variation points of a reception signal and generating a clock to synchronize the reception signal based on an average interval between the variation points.

With this arrangement, it is possible to stably output the clock synchronizing the reception signal, and



EMI. A conventional scrambling technique requires synchronization for scrambling between communications devices, that is not required in the present invention.

Further, in the transmission method according to the present invention, the aforesaid plurality of devices are two devices.

Therefore, even in the case of bidirectional full-duplex operation based on a single wavelength which adopts a single optical fiber as a transmission line, for example, it is possible to prevent an adverse effect of system jitter due to crosstalk which is caused by, for example, reflection of transmission light at an end surface of the optical fiber.

Meanwhile, in a transmission method according to the present invention, the patterns are replaced at a random interval.

Accordingly, a crosstalk light level can be changed at random at the transition of a signal, thereby preventing a sampling point at which a CDR circuit makes sampling of a signal from deviating off the center of the original eye.

Alternatively, in a transmission method according to the present invention, the patterns are replaced at a fixed interval.

Accordingly, since an interval between the

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